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South Africa

EXPLORATION AND EXPLORATORY TECHNIQUES APPLICABLE IN SOUTH-CENTRAL AFRICA

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Item A. Natural Resources.
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REPUBLIC OF SOUTH AFRICA.

EXPLORATION AND EXPLORATORY TECHNIQUES APPLICABLE IN SOUTH-CENTRAL AFRICA.

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1. Introduction:-

South-Central Africa is hereby understood to include that portion of the sub-Continent of Southern Africa extending as far north as East Africa, the former Belgian Congo and Angola. It is, for practical purposes, Africa south of the Equator. This article sets out the writer's views gained as a result of exploration in these territories, with which he has been associated, or has directed, during a period of over thirty years. Exploration for petroleum is excluded as it is highly specialized and can only be carried out, at great expense, by the major oil companies who alone have the necessary facilities.

2. Economic Outlook:-

The scope and length of this article does not permit any details with regard to the regional geology but it can be said that South-Central Africa is one of the highly mineralized areas of the world and one which must continue to play an important part in the search for new mineral deposits to meet the world's future needs.

3. Necessity for Organised and Scientific Exploration:-

South-Central Africa, even in the lesser known areas, is by no means virgin country in the matter of mineral exploration. It has in fact been explored to a greater degree than many supposedly better known territories where difficulties of access, transportation, and a short field-season obtain. This means that the stage has been reached where important mineral fields, at least of the commoner minerals, are unlikely to be discovered by a mere inspection on the ground. Major mineral discoveries here, as in many parts of the world, will be increasingly the result of carefully planned and scientific methods of exploration. (1)

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(1) The only really important mineral discoveries in these territories in recent years have been in the realm of precious stones - diamonds and emeralds.

4. Scope for Individual Prospecting and Small Scale Mining:-

While this applies to major discoveries in general there is still ample scope for the prospector and especially for the small mine worker. There are many mineral fields in Southern Africa where small deposits of economic minerals prevail and where the occurrences of deposits of sufficient size for exploitation on a large scale are the exception rather than the rule. In general, deposits which require no processing and where the ore is sold as such, or where treatment is simple, lend themselves to working on a small scale and such deposits would include certain gold, chrome, asbestos and tin deposits to mention but a few. Certain other deposits such as mica, beryl, corundum, tungsten, etc. seldom lend themselves to exploitation other than on a modest scale.

5. Major Exploration Programmes:-

As we have seen in paragraph 3 the future of exploration in this territory must rely mainly on well planned and scientific methods of exploration and the essential condition is that exploration be carried out or supervised by experienced geologists. Though important surface indications of the presence of the better known minerals have already been found there are good opportunities for further major discoveries. In many regions the evidence of mineral deposits is largely obliterated by intense surface leaching under sub-tropical or tropical conditions of weathering, and over vast areas the underlying formations are masked by a thin cover of wind-blown sand. Close and concentrated work on small areas of favourable ground is more likely to yield results than vast expenditure on large areas without adequate geological direction or supervision. If large exploratory programmes are undertaken the work should be distributed into small groups each working under close supervision.

6. Geological Maps:-

All important exploratory programmes should be based on a geological map of the area to be explored. If the geological information is inadequate a geological map, on a reconnaissance scale, should be made showing in a general way the distribution of the various formations, particularly those which are suspected to contain mineral deposits. By this means work can be devoted to the more promising areas and those with a poor economic outlook discarded.

7. Aids to Exploration:-

During the last few decades certain aids have been available to assist exploration; these are geophysical and geochemical methods of prospecting and aerial photography. These aids have, in many cases, been of great assistance and some of them will undoubtedly be applicable to any major exploratory enterprise. It is the opinion of the writer, however, that too much reliance is often placed upon them at the expense of proper geological groundwork, which is their essential complement. In view of their importance they are discussed in some detail in the succeeding paragraphs inasmuch as their application to conditions pertaining to South-Central Africa is concerned.

8. Geophysical Methods of Prospecting:-

(a) Some misconceptions attach to the role of geophysical methods in exploration. The writer does not claim to have specialised knowledge of the technical details of the various methods but has been a party to the application of most of them; the following remarks are made in the light of his experience under conditions obtaining in these territories. In general geophysical methods suffer from the fact that they are too often regarded as a "magic wand" capable of finding mineral deposits by themselves, whereas in most cases they are merely an aid to the geologist and sometimes, if used without adequate geological control, can be both wasteful and misleading. The fault does not reside in the methods themselves, as physical constants independent of personal factors are measured, but in the interpretation, if based on insufficient knowledge of the geological background or physical conditions pertaining to the terrain in which they are applied. Personal preferences or prejudices also play an important part. Only too often a method, which has given an outstanding result in some particular instance where conditions were exceptionally favourable, is utilized under different conditions where it can be of little if any use. Invariably a geophysical method is first tried out on a deposit, the position of which is known, in order to find out whether it will indicate it and if so extravagant claims are made for it. This, however, is not an infallible guide to its usefulness but only the first hurdle to be overcome. A method which may disclose, by a physical anomaly, the existence of an ore deposit whose presence was previously known may in another, or even in the same terrain, disclose a multiplicity of similar anomalies from which it would be impossible to identify this orebody if its position had not been known. In geophysical prospecting it is the multiplicity of anomalies rather than the lack of them which causes trouble. The foregoing has not been written with the intention of discouraging the application of geophysical methods but of pointing out, in the true interest of these methods, certain limitation to which they may be subject.

(b) Geophysical methods of prospecting include various electrical methods, which either measure naturally occurring fields in the earth's crust or induce currents in the earth artificially. In the writer's experience these methods are those most subject to uncertainties and errors in interpretation and they are more useful in the latter stages of prospecting for the better delimitation of deposits already located. Seismic methods are all important in exploration for oil but are seldom of use for other minerals. Gravity methods have, with the perfection of the modern gravimeter, become more generally useful, but are still of limited application and are more for detailed work. The geophysical methods of prospecting most suitable for general use in exploration for reasons of their adaptability for regional work, their relative low cost and their freedom from most of the uncertainties pertaining to other methods are undoubtedly aerial scintillometer surveys, for radioactive minerals, and aerial magnetometer surveys for magnetic ores, or associated deposits, and some details regarding the application of these methods are therefore of interest.

(i) Aerial Scintillometer Surveys:- Scintillometer or geiger detection of radioactive minerals approaches the ideal geophysical method of prospecting. These are detected directly without any possibility of error or ambiguity. Aerial application by scintillometer is easy and provided flights are carried out low enough any reactions that can be picked up on the ground by geiger counters or scintillometers can likewise be detected in the air. The aircraft to be used must be small and therefore inexpensive and as the installation is easy can usually be hired for the purpose. It is essential to carry out the survey at about 300 feet above the ground and therefore such surveys are limited, both by consideration of safety and for optimum results, to flat country. Very slow speeds are not required provided the speed does not exceed 100 miles per hour. Small one-engined craft are ideal. A serious limitation, especially in this territory, is that radiation is confined to surface exposures or at most a few feet below the surface. In many areas surface leaching is pronounced and this may result in an important radioactive deposit giving but a feeble surface reaction. The strength of the radiation is therefore not necessarily a measure of the value of a deposit and even small anomalies have to be considered which results in a multiplicity of radioactive anomalies which may have to be taken into account. Aerial scintillometer surveys should be carried out on traverses preferably plotted in advance on aerial photographs. A geologist should always be in the aircraft to watch the recording drum as many of the anomalies can be immediately correlated with stream beds, isolated outcrops of granite, etc. and can be discarded as being of no importance.

Although radioactive minerals are being over-produced at the present time scintillometer surveys can be used to prospect for carbonatite occurrences which, though only feebly radioactive, will give strong anomalies in aerial scintillometer work on account of their large mass effect. In East Africa the author directed exploration which quickly confirmed by these means presumed occurrences of carbonatites and likewise disproved the existence of others. In addition several new occurrences were found. An important phosphate body, which contained low uranium values, was also discovered fortuitously by this means.

(ii) Magnetometer Surveys:- This type of survey has the advantage of being a direct method, as far as iron ores are concerned, and an outstanding achievement was the discovery by this means of the large iron ore occurrences in Labrador. The method has also the advantage that it can reveal magnetite bearing deposits at considerable depth and even beneath a cover of younger rocks. In Africa important extensions of the Witwatersrand were discovered, concealed under a thick cover of younger rocks, by defining the position of magnetic shale beds in the footwall of the gold-bearing horizons from which the position of the latter could be predicted. While instrumentation for aerial work is rather costly the rapidity with which aerial magnetometer surveys can be carried out renders the method fairly economical if the area to be explored is a large one. Usually twin-engined aircraft

of moderate size are used and flights carried out about 1,000 feet above the ground and coverage is very rapid. In addition to deposits of iron-ore, the method can be used for the detection of deposits rich in magnetite such as certain carbonatite occurrences, and manganese deposits associated with iron ore have been discovered in the northern Cape by ground methods. It is also useful for tracing magnetic formations in geological mapping which can give important information as to geological structures.

9. Geochemical Methods of Prospecting:-

(a) These methods have been perfected in recent years and have been increasingly employed in Southern Africa. They have the advantage of indicating the presence of various elements without any possible ambiguity and climatic conditions in Southern Africa in general favour their application. Samples are usually taken to conform to a grid pattern and within a foot or less from the surface. The method is rapid and the fieldwork can be reduced to a routine and carried out by unskilled labour. Analysis of the samples can be carried out chemically or spectrographically and when done on a sufficiently large scale costs are moderate.

(b) In the writer's experience, however, the usefulness of this method depends greatly on the conditions obtaining in the terrain in which it is applied. In Southern Rhodesia it has proved very successful in locating deposits of nickel in serpentine and in gabbroidal rocks. Here the surface cover of soil was small and undecomposed rock was to be found at shallow depth and exploration, based on geochemically determined nickel values, pin-pointed nickel deposits fairly accurately. In areas of high rainfall, however, where the surface soil is deep and highly leached the method is not very satisfactory. The dispersion of the elements, especially the more soluble ones, is too great and high geochemical values often have no connection with the underlying rocks, as the elements determined have been transported by surface water over a considerable distance. Under such conditions results serve to indicate possibilities in a regional sense rather than to pin-point individual deposits. In such terrain, however, the writer has used geochemical techniques to good effect in locating the copper-bearing horizon in the Lower Roan Series, to the West of the Northern Rhodesian Copper Belt, and where leaching was so pronounced that no recognisable copper anomaly could be detected at surface. Grab samples were taken at each five feet of depth in prospect pits dug at right angles to the strike at close enough intervals to expose the entire stratigraphic succession. At a depth of about 15 feet in such pits there was sufficient residual copper to disclose the position of the potential "ore shale" when the latter was mineralized. In this case, however, the method was employed rather as a quick means of assay than in its accepted use.

10. Aerial Photography:-

(a) The value of aerial photography has long been recognised. In the realm of exploration it can be put to a variety of uses not so much for the discovery of ore deposits themselves as for ancillary

services connected with exploration; it can prove to be of great assistance in geological mapping; it can be used for compiling topographical maps when existing maps are inadequate; it can serve as a basis to lay out aerial scintillometer grids for which it is almost an indispensable preliminary. For any important exploratory programme, aerial photographic survey is almost certain to be useful in some way or another and on account of its relatively low cost should be made if not available. Fortunately this will rarely be necessary as aerial photography coverage already exists for most territories, having been carried out by various government departments for military or cartographical purposes.

(b) Notwithstanding the great assistance that aerial photography provides in geological mapping it is well to be forewarned against placing too great a reliance on "photogeology" as a sure means of drawing up reliable geological maps. It is legitimate in the case of exploratory enterprises to rely to a considerable extent on aerial photographic work to delineate the more promising geological formations or structures for detailed investigation. In such cases even though ground control has been inadequate and errors may have been made this procedure is justified by the saving of time and expense. It is inadmissible, however, to rely on photo-geology for geological maps intended for public use, such as are compiled by State Geological Surveys. In such cases the results or interpretations based on photo-geology must be rigorously verified on the ground. Even so, photo-geology can be most useful in expediting geological mapping and often provides a quick insight on structures which are not readily discernable on the ground.

11. <u>State Aid</u>:-

(a) The mineral industry is a national asset of great importance and one which can give relatively quick returns, and encouragement of the industry is a wise policy, especially in the case of the lesser developed territories. State aid can be considered under the following headings:-

(i) State Geological Surveys.

(ii) A legislative policy calculated to encourage exploration and large scale mining.

(iii) Subsidies for small mine workers.

(i) A well financed Geological Survey, under whose direction geological maps of the territory will be compiled with particular reference to areas of greater economic promise, is perhaps the most important contribution which can be made by the State for the benefit of the mining industry. Geological Maps are of assistance to all; indispensable in major exploration enterprises they are also of value to the individual prospector. In these days even the humblest prospector, in the writer's experience, does make use

of geological maps, to guide him as to the distribution of certain rock types likely to contain mineral deposits, granite contacts, etc.

The writer is able to testify from personal knowledge to the excellence of the various Geological Surveys in the territories under review. While advocating an enlargement of these activities he would above all stress that the high quality of the present work be maintained and in this respect quality rather than quantity is to be desired. Detailed geological maps of large territories must be gradually built up over a long period but geological maps, even reconnaissance maps, must at all times be accurate in that they should only portray what has actually been observed on the ground without questionable interpretations, or added details, adduced as a result of the study of aerial photographs in an office.

(ii) The formulation of legislation calculated to encourage large scale exploration and mining is a complex subject rather beyond the scope of this article. It must be borne in mind that exploration and mining are very hazardous undertakings where vast sums of money may be spent without any reward so that if private enterprise is to participate in such ventures conditions will have to be made sufficiently attractive. The matter goes beyond that of mere exploration and encompasses the entire field of mining legislation.

In the matter of exploration itself it is now customary to grant large tracts of ground to important mining companies in the form of reserved areas or special grants, etc. for a limited period subject to a stipulated or negotiated yearly expenditure. This is a satisfactory arrangement as it protects the mining company by allowing time to organize exploration on a proper basis and it ensures the State that serious and well organized exploration will be carried out. With regard to possible subsequent mining operations the large mining companies will obviously insist on security of tenure as a first requisite and will expect enlightened legislation in respect of royalties, re-imbursement of prospecting expenses by remission of taxation over an initial period, etc.

(iii) In the case of the small mine worker it will be wise, in deserving cases, to assist him financially. Various means have been devised to do this, notably by loans from Mining Departments conditional upon control or supervision of his activities. In some cases these loans have been guaranteed by the grantee's personal property which the writer believes to be a misguided procedure. It is often difficult to judge if a mining venture will prove successful and this will cause embarrassment to supervising mining officials who will hesitate to encourage further development, so as not to lead the grantee into too much expenditure, and in this way a successful outcome may be prevented. In fairness to all concerned the writer considers that all loans granted for development of deserving properties, under supervision of the mining authorities, should be recoverable only if the venture proves successful and that the State should therefore

participate in the risk. The writer would suggest that perhaps the best way to assist the small worker is to hire out simple mining equipment to him. A large proportion of the cost of developing a property is the cost of equipment and if a venture proves unsuccessful the owner is faced with a large capital loss. If the State through its Department of Mines carries a stock of simple mining equipment such as small hoists, compressors, diesel power units, etc. which they can hire out, at a modest rental to cover depreciation and maintenance costs, the small mine worker can devote most of his resources to developing his property. Such a scheme is in operation in Southern Rhodesia and is proving very popular with small mine owners.

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